

# **AIR QUALITY MONITORING CONSIDERATIONS FOR THE CUMBERLAND/PIEDMONT NETWORK NORTH CAROLINA AND SOUTH CAROLINA UNITS**

January 2002

## **Introduction**

The NPS Air Resources Division (ARD) has contracted with the University of Denver (DU) to produce GIS-based maps that estimate baseline values (with confidence limits) for a set of air quality parameters for all Inventory and Monitoring parks in the U.S. ARD used the DU products to help develop an implementation strategy for expanding NPS air quality monitoring under the Natural Resources Challenge. Based on the implementation strategy, ARD intends to fund installation of a National Atmospheric Deposition Program/National Trends Network (NADP/NTN) wet deposition monitor, a Clean Air Status and Trends (CASTNet) dry deposition monitor, and a wet mercury deposition monitor at Mammoth Cave National Park (NP) in FY 2002. At this time, ARD does not intend to fund additional monitoring at any NPS units in the Cumberland/Piedmont Network. The air monitoring implementation strategy will be revisited in FY 2004 if additional funding becomes available. The Cumberland/Piedmont Network can use the DU products (which will be available on an NPS Intranet site in a few weeks), along with on-site and/or nearby off-site ambient monitoring and natural resource data discussed in this report, to help assess air quality-related conditions and monitoring needs in Network parks.

## **Wet Deposition**

None of the five NPS Cumberland/Piedmont Network units in North or South Carolina have a NADP/NTN wet deposition monitor on-site, but four units have a monitor within 100 km (60 miles). Ninety Six National Historic Site (NHS) has two monitors that are 165 km (about 100 miles) away. NADP/NTN collects data on both pollutant deposition (in kilograms per hectare per year) and pollutant concentration (in microequivalents per liter). Deposition varies with the amount of annual on-site precipitation, and is useful because it gives an indication of the total annual pollutant loading at the site. Concentration is independent of precipitation amount, therefore, it provides a better indication of whether ambient pollutant levels are increasing or decreasing over the years. In general, wet deposition and concentration of sulfate is higher in the eastern than in the western U.S., and in 2000, as in previous years, there were "hot spots" in central North Carolina. In 2000, wet concentration and deposition of nitrate were moderate in North Carolina and South Carolina, with a deposition hot spot in central North Carolina. The same year, wet concentration and deposition of ammonium were low to moderate in the area, with concentration and deposition hot spots in central North Carolina. (see U.S. wet deposition and concentration isopleth maps at <http://nadp.sws.uiuc.edu>). Data from NADP/NTN sites near Cumberland/Piedmont Network parks in North and South Carolina are summarized below.

#### Otto, NC

The Otto, North Carolina, NADP/NTN site (site #NC25 (Coweeta Hydrologic Laboratory)) has been in operation since 1978. The site data show a decrease in concentration and deposition of wet sulfate, and a decrease in deposition of wet nitrate. There has been no overall trend in concentration of wet nitrate, concentration of wet ammonium, or deposition of wet ammonium.

#### Rowan Mills, NC

The Rowan Mills, North Carolina, NADP/NTN site (site #NC34 (Piedmont Research Station)) was installed in 1978. Wet concentration and deposition of sulfate have decreased at the site, but there has been no overall trend in wet concentration or deposition of either nitrate or ammonium.

#### Mount Mitchell, NC

Mount Mitchell, North Carolina, has had a NADP/NTN site (site #NC45) since 1985. To date, site data have not met the completeness criteria required for NADP/NTN to perform trend analyses.

#### Santee National Wildlife Refuge, SC

An NADP/NTN site was installed at Santee National Wildlife Refuge (NWR), South Carolina, (site #SC06) in 1984. Site data show a decrease in wet sulfate concentration, but no trend in wet sulfate deposition. There has been no trend in wet nitrate concentration or deposition. Interestingly, there has been an increasing trend in both wet ammonium concentration and deposition.

Data from the NADP/NTN sites in the area show a decrease in wet sulfate concentration and deposition, which is consistent with a nationwide reduction in sulfur dioxide emissions. While trends in wet deposition and concentration of nitrate and ammonium are not consistent among sites, in most cases, they are either stable or decreasing. The increasing ammonium trends at the Santee NWR site may be due to increased agricultural or animal production activities.

Based solely on spatial distribution, it appears existing NADP/NTN sites in North and South Carolina may not provide adequate coverage for the Cumberland/Piedmont Network. In particular, Ninety Six NHS may not be well represented (particularly since data from the two closest sites—Santee NWR and Otto--show different trends). Cost information is provided in case the Network is interested in installing a new site. A NADP/NTN wet deposition site costs \$5,000 to \$8,000 for equipment purchase and installation, and operating costs (including site operation, chemical analysis, and reporting) are about \$7,000 per year.

#### **Dry Deposition**

None of the five NPS Cumberland/Piedmont Network units in North or South Carolina have a Clean Air Status and Trends Network (CASTNet) dry deposition monitor on-site, but four units have a monitor within 120 km (about 70 miles). The closest monitor to Ninety Six NHS is 190 km (about 115 miles) away. CASTNet uses different monitoring and reporting

techniques than NADP/NTN, so the dry deposition amounts are reported here as nitrogen and sulfur, rather than nitrate, ammonium, and sulfate. In addition, because CASTNet calculates dry deposition based on measured ambient concentrations and estimated deposition velocities, there is greater uncertainty in the reported values. Due to the small number of CASTNet sites nationwide, use of dry deposition isopleth maps is not advised at this time. CASTNet data collected near Cumberland/Piedmont Network parks in North and South Carolina are summarized below.

#### Otto, NC

A CASTNet site has been operating at Otto, North Carolina, (site #COW137 (Coweeta Hydrologic Laboratory)) since 1987. Site data show no trends in dry nitrogen or sulfur deposition. CASTNet estimates total nitrogen deposition at the site consists of 20 percent dry deposition and 80 percent wet deposition, while total sulfur deposition is 15 percent dry and 85 percent wet.

#### Cranberry, NC

Cranberry, North Carolina, has had a CASTNet site (site # PNF126) since 1988. Site data indicate no trends in dry nitrogen or sulfur deposition. CASTNet estimates total nitrogen deposition at the site is composed of 12 percent dry deposition and 88 percent wet deposition, while total sulfur deposition is 13 percent dry and 87 percent wet.

#### Candor, NC

A CASTNet site has been operating at Candor, North Carolina, (site #CND125) since 1990. Site data indicate no trends in dry nitrogen or sulfur deposition. CASTNet estimates total nitrogen deposition at the site is composed of 37 percent dry deposition and 63 percent wet deposition, while total sulfur deposition is 34 percent dry and 66 percent wet.

Based solely on spatial distribution, it appears that Ninety Six NHS is not well represented by existing CASTNet sites. If the Network chooses to install a site, installation and annual operating costs for a CASTNet site are about \$50,000 and \$15,000, respectively.

### **Surface Water Chemistry**

The Water Resources Division's (WRD) *Baseline Water Quality Data Inventory and Analysis* reports were reviewed for the five Cumberland/Piedmont Network parks in North and South Carolina. Data from those reports are summarized below. In general, acid-sensitive surface waters have a pH below 6.0 and an acid neutralizing capacity (ANC) below 100 microequivalents per liter ( $\mu\text{eq/l}$ ).

#### Carl Sandburg Home NHS

A review of the 1998 *Baseline Water Quality Data Inventory and Analysis* report for Carl Sandburg Home NHS indicated data were collected between 1977 and 1993 from many locations in the park, including Memminger and West Creeks, Trout and Duck Ponds, the spring head for drinking water, and Front, Side and West Lakes. The spring head and creeks had average pH values of 5.6 to 5.8, and ANC values of 21 to 50  $\mu\text{eq/l}$ . These data indicate the spring head and creeks are very sensitive to acidification from atmospheric deposition. While the average pH values of the lakes and ponds ranged from

6.0 to 6.7, the ANC values were surprisingly low—42 to 104 µeq/l—indicating the lakes and ponds, too, are susceptible to acidification from atmospheric deposition.

#### Cowpens NB

A review of the 1999 *Baseline Water Quality Data Inventory and Analysis* report for Cowpens National Battlefield (NB) showed no data had been collected inside the park and there was a shortage of recent data available from outside the park. Therefore, based on that report, it was not possible to assess the sensitivity of park surface waters to acidification from atmospheric deposition. According to Joe Meiman, hydrologist at Mammoth Cave NP, recent pH and cation data collected in tributaries at Cowpens NB indicate park surface waters are sensitive to acidification. The Network may want to consider including some of these tributaries in a long-term monitoring program, and monitor acid deposition-related parameters such as pH and ANC.

#### Guilford Courthouse NMP

A review of the 1998 *Baseline Water Quality Data Inventory and Analysis* report for Guilford Courthouse National Military Park (NMP) showed that data collected from one location in the park in 1996-1997 had an average pH of 6.9. Data collected outside the park at Horsepen Creek and Brush Creek in 1974 and 1986-1987 had average pH values of 6.8 to 7.1 and average ANC values of 250 to 400 µeq/l. These data indicate park surface waters are not susceptible to acidification from atmospheric deposition.

#### Kings Mountain NMP

A review of the 1997 *Baseline Water Quality Data Inventory and Analysis* report for Kings Mountain NMP indicated water quality data were collected from 1994 to 1997 on Long Branch, Kings, Dellingham Branch, and Stonehouse Branch Creeks. All creeks had average pH values of 6.9 to 7.3, indicating surface waters in the park are not sensitive to acidification from atmospheric deposition.

#### Ninety Six NHS

A review of the 1997 *Baseline Water Quality Data Inventory and Analysis* report for Ninety Six NHS showed no data had been collected inside the park. Data collected outside the park on Wilson, Ninety Six, and Big Rock Creeks between 1962 and 1997 had average pH values of 6.8 to 7.0 and average ANC values of 400 to 560 µeq/l. If these data are representative of conditions in the park, then surface waters in Ninety Six NHS are not susceptible to acidification from atmospheric deposition.

#### **Visibility**

Visibility-impairing particles and certain gases are monitored in natural areas through the Interagency Monitoring of Protected Visual Environments (IMPROVE) program. Because of the mandates of the Clean Air Act, the IMPROVE program has focused monitoring efforts in Class I air quality areas. Regardless, IMPROVE monitoring provides a regional analysis of visibility; therefore, the data indicate conditions in nearby Class II air quality areas. IMPROVE program staff recently identified an error in past data calculations and are in the process of re-calculating the data. Therefore, trend data are not currently available for IMPROVE sites. All Cumberland/Piedmont Network units

in North and South Carolina have an IMPROVE monitor within 200 km (about 120 miles). The two IMPROVE sites in the region are the Shining Rock Wilderness Area, North Carolina (site #SHRO1; operating since 1994), and the Linville Gorge Wilderness Area, North Carolina (site #LIGO1; new site).

Based solely on spatial distribution, it appears existing IMPROVE sites provide adequate coverage for Cumberland/Piedmont Network parks in North and South Carolina. Installation and annual operating costs for an IMPROVE site are about \$15,000 and \$30,000, respectively.

### **Ozone**

One of the Cumberland/Piedmont Network parks in North and South Carolina, Cowpens NB, has an ozone monitor on-site (monitor #450210002). All other parks are well-represented by monitors within 50 km (30 miles). For future reference, installation and annual operating costs for an ozone monitoring site are about \$90,000 and \$14,000, respectively. According to the map generated by DU, all five Cumberland/Piedmont Network parks in North and South Carolina are likely to have exceedances of the human health-based 8-hour National Ambient Air Quality Standard.

### **Vegetation**

For vegetation, the focus is on ozone sensitivity because 1) ozone is a regional pollutant and is, therefore, more likely to affect park resources than either sulfur dioxide or nitrogen oxide which quickly convert to other compounds, and 2) the literature on ozone sensitivity is more recent and more reliable than that for other pollutants. Park vascular plant lists contained in a May 2001 version of NPSpecies were compared to the general ozone-sensitive plant species lists contained in the NPS Synthesis information management system (see attached Synthesis species lists). The Synthesis lists were developed by an expert in the field of ozone effects on vegetation. Note that the Synthesis lists are a general guide to ozone sensitivity. Differences in plant genetics, weather conditions, water availability, and ozone concentrations will affect whether or not a species exhibits injury in a particular park. Ozone sensitive species of natural vegetation were identified for all five Cumberland/Piedmont Network parks in North and South Carolina (see attached tables of sensitive species for Network parks).

It is generally agreed that plant foliar injury occurs after a cumulative exposure to ozone. One ozone statistic that is used to evaluate the risk of plant injury is the SUM06. SUM06 is the sum of all hourly average ozone concentrations greater than or equal to 0.06 parts per million (ppm). In 1997, a group of ozone effects experts recommended 3-month, 8:00 a.m. to 8:00 p.m., SUM06 effects endpoints for natural vegetation, i.e., 8 to 12 ppm-hrs for foliar injury to natural ecosystems and 10 to 15 ppm-hrs for growth effects on tree seedlings in natural forest stands. According to the SUM06 map generated by DU, all five Cumberland/Piedmont Network parks in North and South Carolina have ozone concentrations, during some years, that are high enough to harm native vegetation. Given this, Network staff may want to conduct foliar injury surveys on sensitive species. Such surveys have been conducted in nearby Great Smoky Mountains NP for a number of years. Good survey species are black cherry (*Prunus serotina*) and common milkweed

(*Asclepias syriaca*) because 1) ozone injury symptoms for these species are well-described and 2) standardized survey protocols and training manuals have been developed.

### **Conclusions**

Four of the five NPS Cumberland/Piedmont Network units in North and South Carolina have a NADP/NTN wet deposition monitor within 100 km (60 miles). Based solely on spatial coverage, Ninety Six NHS may not be well represented by existing NADP/NTN monitors. The state of South Carolina operates its own network of wet deposition monitors. A State monitor is at Cowpens NB, and another is located at Due West, 40 km northwest of Ninety Six NHS. The State's data do not meet the QA/QC requirements of the NADP/NTN program, nor are the State data readily available. However, it is possible that data from existing State and NADP/NTN sites can be combined to provide a more complete picture of wet deposition in the area.

Four of the five NPS Cumberland/Piedmont Network units in North and South Carolina have a CASTNet monitor within 120 km (about 70 miles). Based solely on spatial coverage, Ninety Six NHS may not be well represented by existing CASTNet monitors. South Carolina does not operate a dry deposition monitoring network. Given the cost of dry deposition monitoring, and the fact that surface waters at Ninety Six NHS do not appear to be acid-sensitive, installing a dry deposition monitor is not recommended.

A review of water quality data indicates surface waters at Guilford Courthouse NMP, Kings Mountain NMP, and Ninety Six NHS are not susceptible to acidification from atmospheric deposition. Data indicate lakes, ponds, and especially springs and creeks at Carl Sandburg Home NHS are very sensitive to acidification from atmospheric deposition. Recent data indicate tributaries at Cowpens NB are also acid-sensitive. Long-term monitoring of both pH and ANC in a couple of key creeks at Carl Sandburg Home NHS and a couple of tributaries at Cowpens NB is recommended.

All of the Cumberland/Piedmont Network units in North and South Carolina have an IMPROVE visibility monitor within 200 km (about 120 miles).

All five Cumberland/Piedmont Network units in North and South Carolina are well-represented by existing ozone monitors.

Ozone sensitive species have been identified for all five Cumberland/Piedmont Network units in North and South Carolina. Ozone concentrations are high enough in all five units to warrant foliar injury surveys.

### **Relevant Websites**

NADP - <http://nadp.sws.uiuc.edu/>

CASTNet - <http://www.epa.gov/castnet/>

IMPROVE - <http://vista.cira.colostate.edu/improve/>

Ozone - <http://www.epa.gov/air/data/sources.html>

Pollution sources and air quality data - <http://www.epa.gov/air/data/index.html>

**Ozone-specific sources and data - <http://www.epa.gov/ttn/rto/areas/>**  
**Pollution source and air quality graphics - <http://www.epa.gov/agweb/>**